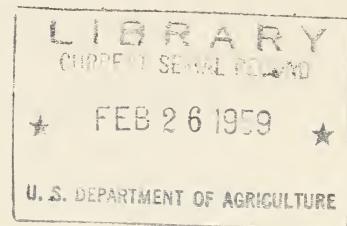


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Kill of Pink Bollworms in the Cotton Gin and the Oil Mill

By O. T. Robertson

V. L. Stedronsky

and D. H. Currie

EXTRA COPY

Production Research Report No. 26

UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with the
TEXAS AGRICULTURAL EXPERIMENT STATION

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Kill of Pink Bollworms in the Cotton Gin and the Oil Mill

By O. T. ROBERTSON, entomologist, *Entomology Research Division*, V. L. STEDRONSKY, principal agricultural engineer, *Agricultural Engineering Research Division*, and D. H. CURRIE, agriculturist, *Plant Pest Control Division*, *Agricultural Research Service*

INTRODUCTION

The pink bollworm (*Pectinophora gossypiella* (Saund.)), discovered as a serious pest of cotton in India in 1842, has now spread to practically all cotton-growing areas of the world. Long-distance jumps have been facilitated by its ability to survive in cottonseed for many months and by commercial movement of the infested seed. Infestation has existed in southwestern Texas for the past 40 years. As a result of gradual spread during this period it now exists throughout the cotton-producing sections of Texas, New Mexico, and Oklahoma and in parts of those of Arizona, Arkansas, and Louisiana. Destruction of pink bollworms by operation of the cotton gin and the cottonseed oil mill is of paramount importance in the control of this insect.

Most of the larvae of late-season generations of the pink bollworm remain in bolls and there enter the diapause, or resting stage, in which, under natural conditions, they live through the winter. Larvae that survive the winter in the field do so mostly in waste cotton remaining after harvest. It has long been recognized that cotton infested with the pink bollworm should be harvested thoroughly and transported in a way that avoids deposition of waste along roadsides, in order that as many as possible of the worms may be carried to the gin rather than left to infest the next year's crop.

In order to prevent or reduce spread of the pink bollworm in this country, Federal and State Governments long ago adopted regulations requiring that gins and oil mills in quarantined areas be provided with special equipment for killing the worm. Such equipment consists of sterilizers for treating cottonseed with heat, fumigation equipment and steel rollers for treating lint and linters, and incinerators or other special equipment for burning or treating gin waste. Installing and operating this special equipment in infested territory has involved costs amounting to many millions of dollars, which have been borne by farmers and processors.

Within the past 25 years mechanical harvesting, with both spindle-type pickers and mechanical strippers, and rougher types of hand harvesting have greatly altered the condition in which seed cotton comes to the gin. This has brought about many changes in ginning techniques and practices and also in the cotton gin itself. The trend has been toward fewer but larger gin plants with sufficient cleaning, drying, and extracting equipment to gin any cotton brought in, whether handpicked, snapped, machine picked, or stripped. The present-day saw gin is an elaborate plant, equipped with many fans, great lengths of pneumatic piping, and considerably more machinery than was used in the past.

As more and more complex gin machinery has been put to use, it has become evident that increasing percentages of kill of the pink bollworms brought to gins in seed cotton are resulting from operation of the gins themselves.

In the period 1953-56 the United States Department of Agriculture, the Texas Agricultural Experiment Station, the Texas Department of Agriculture, and private cooperators carried out investigations to determine the pink bollworm mortality caused in seed cotton, cottonseed, gin trash, and oil-mill byproducts by gin and oil-mill processes and, if possible, to find ways of increasing it. In connection with this research, investigations were made on pink bollworm mortality caused by delinting and hot-water treatment of cottonseed intended for planting. The work was done by staff members of the Southwestern Cotton Ginning Research Laboratory, Mesilla Park, N. Mex.; the Entomology Research Center, Brownsville, Tex.; and the Texas Area of the Plant Pest Control Division, San Antonio, Tex. Tests were made at the ginning research laboratory and at commercial gins, an oil mill, and seed-delinting plants.

SAW-GIN STUDY

Experiments to determine the pink bollworm mortality caused by operation of various kinds of saw-gin machinery were conducted at the ginning research laboratory at Mesilla Park under controlled conditions, and at many commercial gins. Setups of saw-gin equipment ranged from very simple to very elaborate. Items used in different machinery setups were coded as follows:

A, drying equipment (without heat)	E, separator
B, overhead airline cleaner	F, extractor feeder
C, gravity cleaner	G, gin stand
D, bur extractor	H, stick remover

A numeral following the letter "B" or "C" indicates the number of cylinders. To determine the mortality caused by the various gin setups, samples were either examined by hand for pink bollworm larvae or placed in cages equipped with moth traps for recovering the adults.

Ginning Tests at the Laboratory

Infested cottons to be used in the laboratory tests were harvested under supervision from selected fields in Presidio and Pecos Counties, Tex., by either handpicking or snapping and were hauled by truck to the ginning laboratory at Mesilla Park. The gin machinery (fig. 1, table 1) was operated in 16 different setups, those commonly used in commercial gins, at the following speeds:

TABLE 1.—*Piping and air velocities used for moving cotton through saw-gin system in tests at ginning laboratory¹*

Location of pipe	Diam- eter <i>Inches</i>	Length <i>Feet</i>	90° elbows <i>Number</i>	Valves <i>Number</i>	Air velocity <i>F. p. m.</i>
Overflow to separator over distributor-----	12	25.5	2	2	5,160
	16	19	2	2	3,580
Overflow to separator over tower drier-----	12	48	3	2	6,320
Cleaner discharge to separator over distributor-----	16	53	5	3	3,380
Cleaner discharge to separator over 7-cylinder cleaner-----	16	61	4	3	3,380
Tower outlet to upper 6-cylinder cleaner-----	16	49	5	2	3,580

¹ Cotton was fed by gravity or by auger to machinery not mentioned in this table.

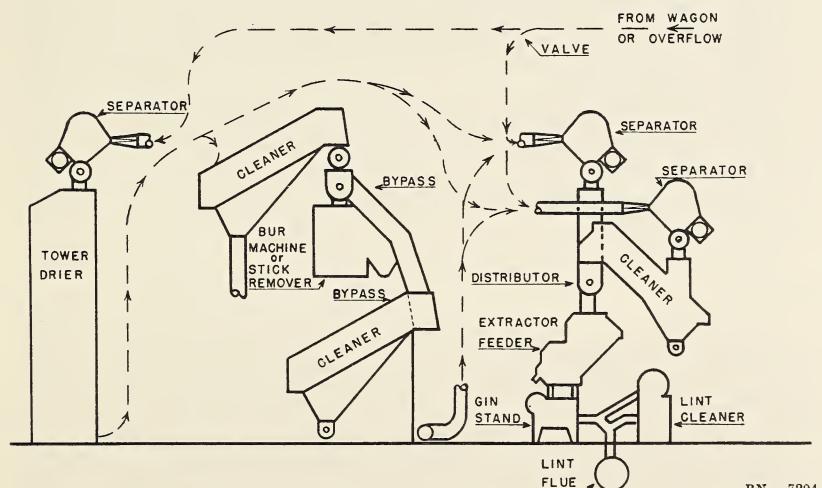


FIGURE 1.—Machinery at the ginning laboratory, including pipes and valves for obtaining the various ginning setups used in the tests.

<i>Ginning unit or equipment</i>	<i>Speed (r. p. m.)</i>
Separator over drier	54
Dropper over drier	54
Upper 6-cylinder cleaner	438
Bur extractor:	
Beater cylinder	345
Main drive for large extractor saw	146
Stripper roll No. 1	354
Stripper roll No. 2	364
Saw cylinder No. 2	89
Picker roller	201
Reclaimer saw	202
Reclaimer doffing brush	481
Doffing brush for large extractor saw	480
Stick remover:	
Drive	635
Saws	755
Brush	1, 200
Lower 6-cylinder cleaner	421
Separator over distributor	124
Dropper over distributor	146
Distributor	192
Separator over 7-cylinder cleaner	85
Dropper over 7-cylinder cleaner	85
7-cylinder cleaner:	
Upper beaters	642
Lower cylinder	410
Reclaimer saw	85
Reclaimer doffing brush	636
Extractor feeder:	
Feed rolls	(¹)
Main drive for upper directional beater	527
Small directional beater	803
Cleaning cylinder	521
Upper picker roll	1, 030
Upper doffing brush	752
Upper large extractor saw	180
Upper reclaimer saw	241
Lower directional beater	527
Lower No. 1 picker roll	1, 016
Large lower extractor saw	145
Small lower extractor saw	198
Doffing brush for large lower extractor saw	699
Lower No. 2 picker roll	707
Lower reclaimer saw	244
Doffing brush for small lower extractor saw	797
Gin stand:	
Saw cylinder	673
Picker roll	202
Huller-front reclaimer saw	80
Reclaimer doffing brush	552
Lint cleaner:	
Condenser screen	19
Doffing rolls	63
Feed rolls	220
Saw cylinder	622
Trash belt	² 359

¹ Variable. ² Feet per minute.

<i>Ginning unit or equipment</i>	<i>Speed (r. p. m.)</i>
Seed belt	2 359
Condenser:	
Screen drum	5½
Doffing roll	21
Directional roll	21
Tramper drive	* 360

* Strokes per minute, 5.

Pink bollworm mortality was determined by hand examination of samples of seed cotton and samples of the cottonseed, lint, and trash obtained by ginning the test cotton.

Cottonseed.—Pink bollworm mortality in seed from cotton ginned at the laboratory with the different machinery setups was determined from samples taken at the gin stand, before the seed passed through the blow system. Any difference between the population found in the seed cotton and that found in the ginned seed was recorded as mortality caused by ginning, in spite of the fact that many live worms enter the flow of gin trash—in which, in commercial gins, they are killed by required trash treatment. (Tests discussed later in this report showed that the blow system increased the mortality considerably.)

In these tests, as in previous general observation, operation of the more complex gin setups was found to cause greater mortality than that of the simplest setups (table 2). Results indicated that in snapped cotton the simplest setup killed about 84 percent of the worms and the most complex killed more than 99 percent. None of the tested setups for which pink bollworm mortality less than 95 percent was recorded would be considered adequate for ginning snapped cotton at commercial gins. For handpicked cotton, the indicated difference between the mortality caused by the simplest setup and that caused by the most complex setup was somewhat less.

Lint.—No live pink bollworms were found in samples of lint from the gin setups.

Gin Trash.—Fractionation of samples of the seed cottons used in these tests showed that waste material per bale averaged 70 pounds in the handpicked cotton and 689 pounds in the snapped cotton. The numbers of live worms per pound found in samples of gin trash (table 3) confirmed the need for special treatment of this material to destroy pink bollworms.

Special Tests at the Laboratory

In addition to the tests on standard saw-gin machinery operated as conventional gins, tests were made at the laboratory on some individual units of such machinery to find their effectiveness in killing pink bollworms.

Saws.—Tests to determine the effects of saw speed and sharpness were made with a gin having 20 saws 10 inches in diameter. The indicated kills with sharp and dull saws were compared at 570 r. p. m. Sharp saws were used for a comparison of the kill at a speed of 570 r. p. m. with that at 865 r. p. m. Three 1-pound samples taken from

the material that was to be subjected to these mechanical treatments contained approximately 300 pink bollworms each.

Indicated kill did not vary significantly according to whether the saws were sharp or dull. It was greater at the higher of the 2 saw speeds, averaging 32 percent at 570 r. p. m. and 77 percent at 865 r. p. m.

Cotton Cleaner.—Seed cotton in 60-pound lots was fed through a 5-cylinder spike-drum cleaner at the rate of 7,200 pounds per hour. The spike drum was 14 inches in diameter and was operated at a speed of 460 r. p. m. There was a clearance of five-eighths inch between the cylinder tip and the (2-mesh) screen. Different lots of cotton were run through the cleaner 2, 4, 8, or 16 times, each of these treatments being replicated 3 times.

TABLE 2.—*Pink bollworm mortality in samples of seed from cotton ginned with various machinery setups at ginning laboratory, 1953-56*

Gin setup ¹	1-pound replicates	Live pink bollworms	
		Estimated total before ginning	Indicated reduction by ginning
Snapped cotton:		Number	Percent
E, F, G-----	5	876	84.2
E, F, G, C7-----	3	496	95.4
E, F, G, E, A-----	2	314	91.7
E, F, G, E, A, C6-----	5	781	93.1
E, F, G, E, A, C6, C6-----	2	308	98.0
E, F, G, E, A, C7-----	3	329	94.5
E, F, G, E, A, C7, C6-----	6	958	96.4
E, F, G, E, A, C7, C6, C6-----	8	1,155	98.2
E, F, G, E, A, C6, D-----	5	920	96.1
E, F, G, E, A, C6, D, C6-----	5	970	98.4
E, F, G, E, A, C6, D, C6, C7-----	8	1,102	99.3
E, F, G, E, A, C6, D, C6, C7, E-----	2	318	99.7
E, F, G, E, H-----	3	528	94.5
E, F, G, E, H, A, C6-----	3	555	98.0
E, F, G, E, H, A, C6, C7-----	3	613	98.5
E, F, G, E, H, A, C6, C7, C6, E-----	3	804	99.5
Handpicked cotton:		Number	Percent
E, F, G-----	4	722	92.2
E, F, G, C7-----	3	669	96.6
E, F, G, E, A-----	1	98	98.0
E, F, G, E, A, C6-----	1	102	99.0
E, F, G, E, A, C6, C6-----	1	98	99.0
E, F, G, E, A, C6, C6, C7-----	4	713	99.2
E, F, G, E, A, C6, C7-----	3	765	98.4
E, F, G, E, A, C6, C7, H-----	3	578	99.5

¹ Code is given on p. 2.

TABLE 3.—*Pink bollworm* survival in gin trash from different units of cleaning equipment and in gin motes at ginning laboratory, 1953-56¹

Gin setup ²		Live pink bollworms found per pound of trash from—				Live pink bollworms per pound of gin motes	
		First 6-cylinder cleaner Number	Stick re-mover or bur Number	Second 6-cylinder cleaner Number	7-cylinder cleaner Number	Extractor feeder Number	Huller Number
Snapped cotton:							
E, F, G						10.8	5.4
E, F, G, C7						3.9	1.3
E, F, G, E, A						2.0	0
E, F, G, E, A, C6		47.0				1.2	1.0
E, F, G, E, A, C6, C6		2.0				2.0	.5
E, F, G, E, A, C7, C6		9.4				.5	1.0
E, F, G, E, A, C7, C6, C6		20.0				.6	1.0
E, F, G, E, A, C7, C6, D		9.0	3.3.6			.6	.2
E, F, G, E, A, C6, D		10.4	3.3.8	17.2		3.7	1.3
E, F, G, E, A, C6, D, C6		6.7	3.2.8	12.2	9.4	1.2	.9
E, F, G, E, A, C6, D, C6, C7				21.7		0	.3
E, F, G, E, H, H						3.7	2.7
E, F, G, E, H, A, C6		14.3	8.8			1.0	.8
E, F, G, E, H, A, C6, C7		6.2	4.4			.9	.7
E, F, G, E, H, A, C6, C6, C7, E		8.8	3.0	(4)	9.1	.4	.6
Handpicked cotton:							
E, F, G						30.2	4.2
E, F, G, C7						44.0	4.0
E, F, G, E, A						13.0	0
E, F, G, E, A, C6		24.0				14.0	13.0
E, F, G, E, A, C6, C6		20.0		36.0		7.0	0
E, F, G, E, A, C6, C6, C7		27.3		62.5	44.0	16.5	0
E, F, G, E, A, C6, C7		29.2			33.1	29.1	.9
E, F, G, E, A, C6, C7, H		27.3			34.6	16.4	.4
						8.8	0

¹ No live worms were found in lint-cleaner trash.

² Code is given on p. 2.

³ Bur extractor.

⁴ No data available.

Three 1-pound samples taken before treatment, 1 from each lot, contained about 300 worms each. Samples taken after treatment indicated that pink bollworm mortality averaged 54, 92, 98, and 100 percent for the 4 treatments, respectively.

Cotton Drier.—Because hot air, ordinarily, is applied in the cotton drier only when dampness of cotton makes it necessary, application of heat was omitted in all but one of the cotton-drier experiments. In this experiment the cotton was exposed to an air temperature of 250° F. for the short period that would normally be required for it to pass through the drier. The cotton moved from overflow to separator, to drier, to separator, to 7-cylinder cleaner, to distributor, to extractor feeder, to gin. Samples were taken after it passed through the extractor feeder.

For lots that contained approximately 300 pink bollworms per 3 pounds before entering the gin machinery, results indicated that pink bollworm mortality was 97.4 percent when heat had been applied in the drier and averaged 94.2 percent when heat had not been applied.

Seed-Blow System.—In the experiments with different gin setups, cottonseed dropped from the seed belt into a vacuum dropper and thence into a 5-inch pipe that conveyed it by air to a hopper. Engineering data on the conveyer were as follows:

Pipe (5-inch)-----	feet	65
Elbows (90°, 36-inch-radius)-----	number	4
Air volume per minute-----	cubic feet	600
Air velocity per minute-----	feet	4,420

For 26 seed lots, totaling 78 pounds, that contained about 446 live pink bollworms before passing through the blow system, the count of live worms after treatment was 252, indicating a mortality of 43.5 percent.

Stick Remover.—A recent development in cotton-cleaning machinery is the stick remover. This machine operates on a new principle in removing sticks, limbs, and other foreign matter from seed cotton. It was tested at 3 speeds in a gin setup that was very simple and in another that included a 7-cylinder cleaner.

Before ginning, the cotton used in these tests contained about 2,100 pink bollworms per 18 pounds. Indicated kill did not vary significantly according to whether the machine was operated at a speed of 867, 813, or the normal 730 r. p. m. It averaged 95 percent for the very simple setup and 97 percent for the one containing the 7-cylinder cleaner. Other experiments in the ginning laboratory (those for which data are given in table 2) yielded evidence that the stick remover killed pink bollworms as effectively as a 6- or 7-cylinder cleaner.

Tests of Commercially Ginned Seed

To determine the effectiveness of commercial gins in killing pink bollworms, samples of seed cotton and cottonseed were obtained from 28 such gins and were examined by hand. Infested seed cotton to be used in tests had been brought from selected fields or selected on the

basis of sampling at the gin yard. The seed samples were taken at the gin stand, and any pink bollworm mortality that might have occurred in the seed conveyer was not determined.

In the hand-examination tests, as in those made at the ginning laboratory, the indicated kill of pink bollworms averaged greater for the most complex than for the least complex of the gin setups (table 4). For 11 of the 23 setups, used in 16 gins, it was 100 percent in at least 1 gin each, and for only 5 of the 23 was it less than 97

TABLE 4.—*Pink bollworm mortality caused in cotton from heavily infested areas of Texas by ginning operations of 28 commercial plants, as determined by hand examinations, 1953-54*

Gin setup ¹	Live pink bollworms in 1-pound samples of material ginned by individual plants	
	Estimated total before ginning	Indicated reduction by ginning
E, F, G, C6-----	162	98. 8
E, F, G, C7-----	86	89. 5
E, F, G, A, C9-----	47	100
E, F, G, A, C6, C6-----	105	99. 4
E, F, G, A, C6, C6, E-----	26	100
E, F, G, A, C6, C7, B4-----	33	97. 0
E, F, G, A, D, C7-----	16	98. 5
E, F, G, A, D, C7, C6-----	125	96. 8
E, F, G, A, D, C7, C6-----	33	100
E, F, G, A, D, C7, C5, B4-----	59	100
E, F, G, A, D, C7, C5, B4-----	149	100
E, F, G, A, D, C7, C7, B4-----	429	100
E, F, G, A, D, C8, C8, B4-----	150	97. 3
E, F, G, A, D, C8, C8, B4-----	163	98. 8
E, F, G, A, D, C11, C5, B4-----	287	95. 3
E, F, G, A, D, C11, C5, B4-----	161	100
E, F, G, A, D, A, C11, C13, B6-----	658	99. 2
E, F, G, A, D, E-----	82	100
E, F, G, A, D, E, C6-----	79	96. 2
E, F, G, A, D, E, C6, C7-----	33	100
E, F, G, A, D, E, C6, C7-----	20	93. 0
E, F, G, A, D, E, C7, C6-----	173	97. 7
E, F, G, A, D, E, C7, C7, B4-----	551	98. 0
E, F, G, A, D, E, C7, C7, B6-----	156	98. 7
E, F, G, A, D, E, C7, C5, C4, B4-----	252	99. 2
E, F, G, A, A, D, E, C9, C15-----	76	100
E, F, G, A, D, E, E, A, C6, C4-----	63	100
E, F, G, A, D, E, E, A, C7, C7, C7-----	81	100

¹ Code is given on p. 2.

percent in any gin. The lowest kill, 89.5 percent, was that indicated for 1 of the 2 gins having the least complex setups.

Further information on the pink bollworm mortality in seed and on the danger of spread of infestation involved in planting unsterilized seed was obtained in cage tests. Commercially ginned planting seed was obtained from growers in central Texas, where seed sterilizers were not operated, and was stored until the usual time of planting. Then 900 pounds of this seed, comprising a 100-pound lot from each of 9 gins having intermediate machinery setups, was placed on the soil surface in cages and thoroughly wet to stimulate pupation of any pink bollworms that might be present. Other lots of unsterilized commercially ginned seed from areas known to be heavily infested, totaling 436 pounds, were planted in cages in a manner simulating normal planting.

No moths emerged from any of the seed lots that were caged unplanted, and only 7 emerged from the lots that were planted (table 5).

TABLE 5.—*Pink bollworm moth emergence from commercially ginned seed, produced in heavily infested areas of Texas, that was planted in cages, 1953–55*

Gin setup ¹	Weight of seed lots planted	Estimated total of live pink bollworms		Moths
		Before ginning	After ginning	
E, F, G, C4, C7, C7, A, D-----	Pounds 32	Number 7,648	Number 336	2
E, F, G, C2, C6, C6, A, E, D---	9	567	0	1
E, F, G, C6, A, D-----	31	2,449	93	1
E, F, G, C4, C7, C7, E, A, D---	70	44,080	0	0
E, F, G, C9, C11, A, D-----	20	11,740	220	3
E, F, G, C4, C6, E, A, D-----	{ 40 218	----- -----	500 622	0 0
E, F, G, C7-----	16	1,200	48	0

¹ Code is given on p. 2.

The results of these tests indicate that within a generally infested area little hazard is involved in planting unsterilized locally produced cottonseed. Emergence of moths from any planting seed used in such an area is of minor consequence in comparison with that from waste cotton left in fields. However, planting unsterilized seed produced in an infested area must be considered a quarantine risk; and if seed originating in such an area is to be planted in an area not known to be infested, the seed should be treated to assure the kill of all pink bollworms.

Survey of Saw Gins in the Quarantined Area

A survey was made of the cleaning and ginning equipment of all the saw gins in the pink bollworm quarantined area. The machinery in each gin was coded as in the ginning experiments, and a record was made of the number of bales ginned by each in 1955. The efficiency of each gin in killing pink bollworms was then estimated on the basis of results of the ginning experiments.

Of the 2,340 saw gins in the quarantined area, equipment estimated to kill less than 90 percent of pink bollworms was found in only 47; and less than 1 percent of the cotton produced in the area was ginned on these 47 plants. Gins classified as equipped to kill at least 95 percent of pink bollworms numbered 2,019, and their output of cotton made up 94 percent of the year's total for the quarantined area.

ROLLER-GIN STUDY

A small-scale study was made, at the ginning laboratory, with the following setup of roller-gin machinery: Separator, 7-cylinder cleaner, overflow, separator, Pima unit, convertible extractor feeder, and 54-inch roller gin. Infested seed cotton, weighed out in 25-pound lots, was fed from a suction pipe into the pneumatic handling layout shown in table 6. The machinery was operated at the following speeds:

<i>Ginning unit or equipment</i>	<i>Speed (r. p. m.)</i>
Separator over feed hopper	129
Dropper over feed hopper	41
Dropper under feed hopper	41
Separator over Pima unit	100
Dropper over Pima unit	32
7-cylinder cleaner	469
Drive for Pima unit	416
Drive for convertible extractor feeder	436
Gin stand (54-inch):	
Roller	120
Doffer	35
Moving knife	1 810
Motors:	
Main, 60 hp	1, 760
Suction, 25 hp	1, 620
Trash, 25 hp	{ 1, 620 2, 144

¹ Strokes per minute.

Samples of the seed cotton were taken before ginning, and seed samples were taken at the gin stand.

In material that contained approximately 300 worms per 3-pound sample before ginning, the indicated mortality amounted to 85 percent. In similarly infested material that passed through the roller gin stand alone, bypassing all other units, it was only 6 percent.

A high survival in roller gins has no great consequence, as roller gins in the infested area total only 16 and gin only a small part of the cotton crop, that made up by American-Egyptian varieties. Furthermore, planting seed of any American-Egyptian variety is

given one of the approved treatments discussed in the next section, which kill all surviving pink bollworms.

TABLE 6.—*Piping and air velocities used for moving cotton through roller-gin system in tests at ginning laboratory*

Location of pipe	Di- ameter	Length	Elbows	Elbow angle	Valves	Air velocity
Suction to separator over feed hopper-----	Inches 12½	Feet 86	Number 4 3	Degrees 90 45	Number 2	F. p. m. 3, 520
Blow box to tower inlet-----	14½	33	2 1	90 15	1	1, 710
Blow box to Pima inlet-----	14½	31	3 1	90 15	2	3, 960
Tower to 7-cylinder cleaner-----	14½	50	3 1	90 45	1	3, 760

TREATMENT OF PLANTING SEED

Delinting

Farmers increasingly prefer delinted cottonseed for planting. At present, in some sections of the pink bollworm infested area only about 20 to 35 percent of the cottonseed intended for planting is delinted, but in southwestern Texas, southern New Mexico, and the infested area of Arizona the proportion has increased to about 99 percent. Commonly used methods of delinting are the mechanical, the mechanical plus flaming, and the acid.

Tests to determine the pink bollworm mortality caused by each of these three methods were made in commercially operated delinting plants. Estimates of the live worm population before and after delinting were based on examination of extremely large samples, because of the very low point to which infestation had been reduced by ginning.

Mechanical Delinting.—Mechanical delinting of planting seed is done with saws by the same method used to remove linters at the oil mill. It was tested on 200 pounds of seed in a plant at Lamesa, Tex. This seed, on an average, contained only about 5.5 pink bollworms per pound before delinting. Examination of samples amounting to 10 pounds taken after the first-cut delinting indicated a mortality of 96.4 percent. No live worms were found in a 10-pound sample taken after the second-cut delinting. This does not mean that second-cut delinting has been proved to kill all pink bollworms surviving the first-cut delinting.

Mechanical-Flame Delinting.—The mechanical-flame delinting method consists in removing a part of the linters with saws and burning the remainder with a gas flame. It was applied to 100 pounds of seed in a plant at Mesquite, N. Mex. The seed advanced as follows: Separator, delinting stand, first flaming, hopper, polisher, cooling, culling, second flaming, cooling, fungicide treatment, and sacking. Temperature of the seed ranged from 160° to 175° F. for 5 minutes after the first flaming. It rose to 153° at the second flaming, after the culling, and had decreased to 110° at the time of sacking.

In samples totaling 21 pounds and estimated to contain 692 live worms before treatment, a survival of 7.5 percent was indicated after the mechanical delinting alone, but no live worms were found in comparable samples taken after the flaming. It was concluded that mechanical-flame delinting killed all the worms. Other methods of mechanical-flame delinting may not give the complete kill obtained in this experiment.

Acid Delinting.—Seed lots totaling 1,000 pounds were run through an acid delinting plant at Pecos, Tex. The seed passed through 6 cylinders during the acid treatment, through 3 other cylinders during the washing, and then through the drier. Its temperatures stood at 120° F. for 1.5 minutes in the second acid-treatment cylinder, rose to 134° in the 5-minute period required for passing from the second through the fifth cylinder, and was 142° for 1 minute in the sixth cylinder. After the washing, the seed was exposed to air at 340° for 45 seconds in the drier. When discharged from the drier, it had a temperature of 146°.

No live worms were found by hand examination of 80 pounds of seed estimated to contain 1,863 live worms before the delinting. It was concluded that all pink bollworms in the seed were killed by the complete acid delinting, washing, and drying process. Examination of samples, totaling 18 pounds and estimated to contain 419 live worms before treatment, that received the acid and washing treatment but did not pass through the drier indicated a survival of 1.2 percent.

Hot-Water Treatment

A recently adopted method of treating cotton planting seed, particularly that of American-Egyptian varieties, to hasten germination consists in immersing the seed in water at temperatures between 160° and 180° F. for 1 to 2 minutes. An experiment was conducted to determine whether such treatment would assure destruction of all pink bollworms in infested seed.

As has been reported by Clark,¹ no pink bollworms survived when seed was immersed in water at 150° F. or a higher temperature for as long as 45 seconds.

¹ CLARK, E. W. THE EFFECT OF HOT-WATER TREATMENT FOR HARD COTTONSEED ON A PINK BOLLWORM INFESTATION. Jour. Econ. Ent. 50: 795-796. 1957.

TREATMENT OF GIN TRASH

Use of incinerators to dispose of gin trash has created serious problems in some localities because of the smoke and the fire hazard. In recent years increased demand for gin trash, which is used for soil improvement and as stock feed, has intensified the need for an economical method of eliminating pink bollworms from it. Work toward determining the effectiveness of various kinds of trash-disposal machinery in killing pink bollworms and toward developing trash-disposal equipment more effective in this respect was done at the ginning laboratory and at commercial gins.

Tests at the Laboratory

In separate tests, infested materials were put through trash beater, beater plus fan, fan with attrition hub, dual fan, and 19-inch and 32-inch single fans used to blow trash from the normal ginning operation. Apparatus was operated at different speeds. The infested materials used were snapped bolls, gin trash plus cottonseed, and a mixture of bolls, seed, and trash.

In a large proportion of the tests some pink bollworms survived. Results showed, however, that it is possible to obtain a complete kill with a single 32-inch fan operated at a rate of 2,144 r. p. m.

Conditions of the tests were more favorable for pink bollworm survival than those of the normal ginning operation. In the mixture of seed and trash, the seed were much more numerous than they ordinarily are in waste from normal ginning. Also, the impact required to kill worms in bolls was found to be greater than that necessary to kill worms in seed and gin trash.

A recent development in the treatment of gin waste is use of rubber lining in trash-fan housings to reduce wear resulting from abrasion by the sand from seed cotton. Ginners have found that such lining lengthens the life of the fans, thereby reducing operation costs. Tests were conducted at the ginning laboratory to determine whether fans having a rubber lining in the steel or cast-iron housing were as effective in killing pink bollworms as fans not having such a lining.

A No. 30 Murray² trash fan having a 19-inch wheel diameter was used with and without a rubber lining in its housing. It was tested at a hub speed of 2,520 r. p. m. with a tip speed of 12,500 f. p. m. and at a hub speed of 2,730 r. p. m. with a tip speed of 13,568 f. p. m. For use in these tests, heavily infested cottonseed that had been ginned on a roller gin to prevent injury to the larvae was mixed with gin trash at the rate of 1 pound of seed to 4 pounds of trash. The mixture was run in four replications for each speed of the fan. Samples that totaled 75 pounds and were estimated to contain 714 live larvae before treatment were examined after treatment.

² Use of a trade name for identification does not imply recommendation by the United States Department of Agriculture as to price or quality of a manufacturer's product.

No live worms were found in the samples treated at either 2,520 or 2,730 r. p. m. It was concluded that the rubber lining had no effect on the pink bollworm kill.

Further tests with fans having rubber lining are discussed under the heading "Treatment of Oil-Mill Byproducts."

Tests at Commercial Gins

Tests made to determine the pink bollworm kill resulting from operation of trash-disposal machinery at commercial gins involved fans of many different sizes operated at various speeds (table 7). There were 60 such tests, all made with trash from cotton grown in heavily infested areas of Texas. Some of the trash samples were from cotton grown at San Angelo and ginned at 7 different plants in northwestern Texas; the others were from locally grown cotton ginned at 13 plants in the Lower Rio Grande Valley, 5 in the Winter Garden-Eagle Pass section, and 2 at Port Lavaca. The cotton was so selected as to represent infestations of more than average severity for the respective areas. Each selection was based on an infestation count made in the field; on cutting of seed in samples of seed cotton; or on observation of the extent of damage to the cotton and the abundance of free worms in the vehicle in which the cotton was brought to the gin and in the first cleaner waste during the ginning.

In each test, trash from one-half bale to five bales of handpicked or snapped cotton was collected as it was discharged by the fan. This waste came from all the cleaning machinery except the rock catcher. If discharged into a cyclone settler, it was caught in a canvas bag under the cyclone; if it would normally have been discharged directly from the outlet pipe into an incinerator or a compost pit, it was collected in a catcher, designed for the purpose, that had been installed at the discharge end of the outlet pipe or at a convenient place between the fan and that point. A 50-pound sample from each test was caged for moth emergence.

Pink bollworms survived only in trash treated with fans the wheels of which were 20½ inches or less in diameter and were operated at tip speeds of 12,300 f. p. m. or less (table 7). This result led to changes in quarantine requirements, discussed later.

TREATMENT OF OIL-MILL BYPRODUCTS

In preliminary work to determine the effectiveness of oil-mill processes in killing pink bollworms, infested cottonseed was put through the standard oil-mill process in a modern plant at Lubbock, Tex. Of the estimated total number of pink bollworms in the seed, 26 percent survived the first delinting and 1.8 percent survived the second. Large numbers of live worms were found in the shaker waste. Some were found in motes that had not yet passed through the mote beater, but none in motes that had done so. Limited examinations did not reveal any live worms in linters, in lint-beater waste, or in seed hulls or meats.

TABLE 7.—*Pink bollworm moth emergence in gin trash, from heavily infested cotton ginned at commercial plants, that was variously treated with single fans*

Tip speed (f. p. m.)	Fan speed	Fan wheel diameter	Tests	Trash caged	Moths
	<i>R. p. m.</i>	<i>Inches</i>	<i>Number</i>	<i>Pounds</i>	<i>Number</i>
10,850-----	2, 325	18	4	200	2
11,000-----	2, 100	20	2	100	2
11,930-----	2, 400	19	3	150	2
12,300-----	2, 294	20½	4	200	2
12,425-----	2, 025	23½	1	50	0
12,720-----	2, 025	24	3	150	0
12,760-----	2, 255	22	3	150	0
12,800-----	1, 750	28	1	50	0
13,290-----	1, 880	27	1	50	0
13,400-----	1, 970	26	1	50	0
13,430-----	1, 900	27	3	150	0
13,500-----	2, 200	23	1	50	0
13,580-----	1, 620	32	6	300	0
13,705-----	1, 745	30	1	50	0
13,800-----	2, 250	23½	1	50	0
13,900-----	2, 590	20½	1	50	0
14,000-----	2, 275	23½	1	50	0
14,100-----	2, 700	20	1	50	0
14,140-----	2, 000	27	3	150	0
14,200-----	1, 780	30½	1	50	0
14,225-----	2, 090	26	2	100	0
14,300-----	2, 670	20½	1	50	0
14,450-----	2, 400	23	2	100	0
14,560-----	2, 225	25	1	50	0
15,390-----	2, 100	28	1	50	0
15,850-----	2, 300	26½	2	100	0
16,200-----	1, 935	32	1	50	0
16,261-----	2, 300	27	1	50	0
17,290-----	2, 144	32	6	300	0
17,950-----	2, 450	28	1	50	0

Further tests were conducted with equipment available at the ginning laboratory. Infested linters, motes, and hulls were put through fans of the kind commonly used to move motes and linters to the press. Separate tests were made with these byproducts, to which infested seed had been added to provide a high worm population. Seed was added at the rates of 1 pound to 9 pounds of linters or motes and 1 pound to 4 pounds of hulls, and was thoroughly mixed with these materials before the tests.

Fans with unlined steel or cast-iron scrolls were tested first. Later a fan with a rubber-lined scroll was tested to determine whether the rubber lining decreased the kill. Descriptions of the fans used, the

speeds at which they were operated, and the results are given in table 8.

TABLE 8.—*Pink bollworm survival in oil-mill byproducts¹ fed into fans of different blade lengths, with and without scroll linings, at air velocity of 5,800 f.p.m.*

Fan description	Hub speed	Tip speed	Live pink bollworms	
			Estimated total before treatment	Found after tests
With unlined scroll:				
No. 25, 18-inch blade-----	<i>R. p. m.</i> 1, 963 2, 500 2, 992	<i>F. p. m.</i> 9, 250 11, 800 14, 100	<i>Number</i> 326 489 489	<i>Number</i> 0 0 0
No. 30, 19-inch blade-----	2, 895	14, 400	489	0
No. 35, 24-inch blade-----	2, 300	14, 450	673	0
No. 35, 27-inch blade-----	<i>R. p. m.</i> 1, 606 1, 793 2, 050	<i>F. p. m.</i> 11, 350 12, 680 14, 500	<i>Number</i> 489 489 489	<i>Number</i> 1 0 0
With rubber-lined scroll: No. 30, 19-inch blade-----	<i>R. p. m.</i> 2, 470 2, 700	<i>F. p. m.</i> 12, 300 13, 420	<i>Number</i> 1, 503 1, 503	<i>Number</i> 0 0

¹ The material used in tests with unlined scroll totaled 1,820 pounds; that used in tests with lined scroll, 288 pounds.

Conditions of all the tests were highly favorable for survival of the pink bollworm as compared with conditions in normal oil-mill operations. The materials contained many more infested seed than they would have under normal conditions. Further, since the infested seed added to them did not pass through linter saws, beaters, and other machinery normally used in the milling, the larvae in these seed were in better condition to withstand the impact of the fan than they would have been under usual milling conditions.

The material subjected to 8 different treatments (table 8) with fans having unlined scrolls totaled 1,820 pounds and contained approximately 4,000 live worms before treatment; that treated with the fan having a rubber-lined scroll totaled 288 pounds and contained approximately 3,000 worms before treatment. No survival was found except in a single instance. In that instance 1 worm survived out of a total estimated at 489 in 75 pounds of material treated with a 27-inch fan, having no scroll lining, that was operated at 1,606 r. p. m. and a tip speed of 11,350 f. p. m.

The results of the tests were favorable toward the possibility of killing all pink bollworms in linters and oil-mill byproducts with fans of specific kinds operated at specific speeds, and indicated that rubber lining of the fan scroll had no effect on the kill. The practical

outcome of the tests with regard to quarantine requirements is set forth in the next section.

CHANGES IN QUARANTINE REQUIREMENTS³

The work reported in this publication has brought about several changes in pink bollworm quarantine requirements of the Plant Pest Control Division, Agricultural Research Service, and the States of Texas and New Mexico. These changes are now saving cotton growers and processors an amount estimated at more than \$3 million a year.

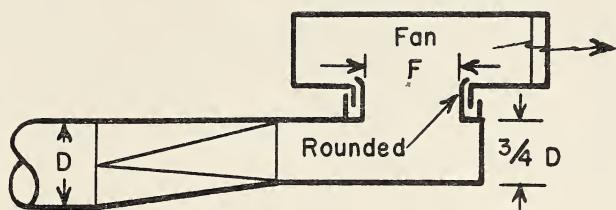
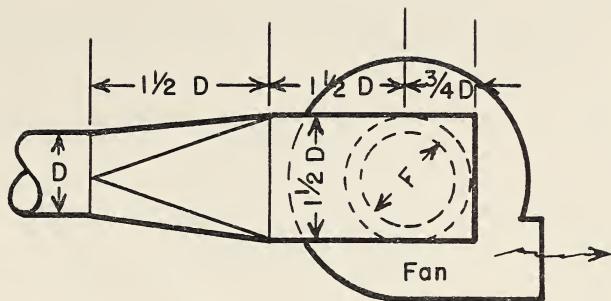
For treating gin trash that is to be released for local use as stock feed and for soil improvement, Federal quarantine requirements now permit cotton growers and processors to use single fans designed according to specifications presented here in table 9 and figure 2. In addition to meeting these specifications regarding fan wheel diameter, speeds, and piping inlets, single-fan gin-trash systems must meet the following requirements: (1) No fan shall be used with a wheel diameter of less than 19 inches; (2) the housing or scroll shall be constructed of plate steel or cast iron; (3) patching of housing shall be by approved welding methods or plate or cast insertions; (4) no gin trash fan wheel shall be used in an oversized casing, but oversized or standard wheels may be used in standard casings only; (5) the wheel must be laterally centered to have equal clearance front and back; (6) gin fan trash wheels shall be of standard straight-blade construction, having not less than 6 full blades; and (7) inlet pipe must come straight to fan eye for a distance of at least 4 times the diameter of the pipe. Approved close-connection elbows may be used if required straight inlet cannot be achieved.

WARNING—Engineering research indicates that tip speed of gin trash fans should never exceed 15,000 f. p. m., for safety to life, limb, and equipment.

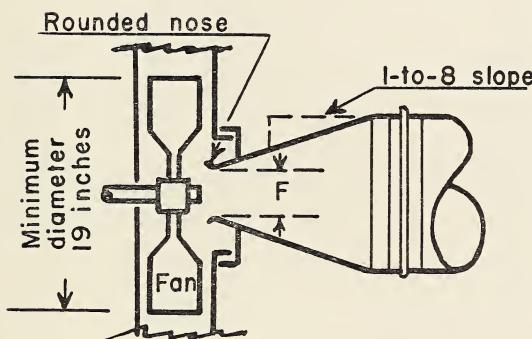
For treating oil-mill byproducts, the present revised Federal requirements permit use of single fans designed according to specifications presented here in table 10 and figure 3. In addition to meeting these specifications regarding fan wheel diameter, speeds, and piping inlets, single fans for handling cottonseed hulls, linters, and motes must meet the following requirements: (1) No fan shall be used with a wheel diameter of less than 18 inches; (2) the housing or scroll shall be constructed of plate steel or cast iron; (3) patching of housing shall be by approved welding methods or plate steel or cast iron insertions; (4) no fan conveying hulls, linters, or motes shall have a wheel in an oversized casing, but oversized or standard wheels may be used in standard casings; (5) the wheel must be laterally centered to

³ For complete information on the pink bollworm quarantine, consult the Plant Pest Control Division, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

A



B



BN-7203

FIGURE 2.—Federal pink bollworm quarantine design specifications for single fan to be used in treating gin trash that is to be released for local use as stock feed and for soil improvement. A, Close-connection elbow. B, Fan inlet adapter for oversized pipe. The adapter must extend past the housing wall to permit trash to enter the fan wheel. ("F" signifies the diameter of the fan inlet.)

have equal clearance front and back, and must be centered in the scroll; (6) the fan wheel shall be of standard straight-blade construction, having not less than 6 blades; and (7) inlet pipe must come straight to fan inlet for a distance of at least 4 times the diameter of the pipe.

WARNING—Engineering research indicates tip speed of straight-blade fans should never exceed 15,000 f. p. m., for safety to life, limb, and equipment.

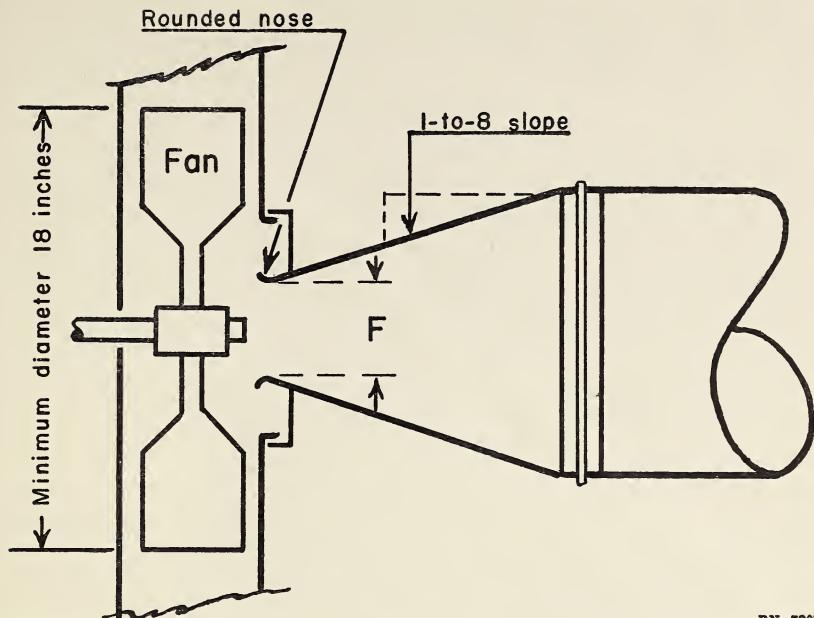
TABLE 9.—*Federal pink bollworm quarantine requirements regarding wheel diameter, inlet size, and speed of operation of single fans for treating gin trash*

Fan wheel diameter (inches)	Maximum inlet size	Minimum speed	Maximum safe speed
19	<i>Inches</i>	<i>R. p. m.</i>	<i>R. p. m.</i>
19½	10 to 10½	2, 760	3, 020
20		2, 690	2, 940
20½		2, 620	2, 860
21		2, 560	2, 790
21½		2, 490	2, 730
22	10½ to 11	2, 430	2, 660
22½		2, 380	2, 610
23		2, 330	2, 550
23½		2, 280	2, 490
24		2, 230	2, 440
24½		2, 180	2, 390
25	11½ to 12	2, 140	2, 340
25½		2, 090	2, 290
26		2, 100	2, 250
26½		2, 060	2, 200
27		2, 020	2, 160
27½		1, 980	2, 120
28		1, 940	2, 080
28½		1, 910	2, 050
29		1, 880	2, 010
29½	12 to 12½	1, 840	1, 980
30		1, 810	1, 940
30½		1, 790	1, 910
31		1, 750	1, 880
31½		1, 725	1, 850
32		1, 700	1, 825
32½		1, 700	1, 790
		1, 700	1, 760

Use of fans meeting these requirements at gins and oil mills, instead of the more expensive fans formerly specified, has been adopted generally in the quarantine area.

Evidence produced by the investigations regarding kill of pink bollworms in the modern cotton gin and the additional kill caused by oil-mill processes or by planting-seed treatment has led to abolition by Texas and New Mexico of their regulations requiring heat treatment of cottonseed at gins. The evidence has led to the conclusion that under present practices pink bollworm survival is of little, if any, importance when the seed is used within the generally infested area. (At the time of publication of this report Arizona, Arkansas, and Louisiana continue to require heat treatment of cottonseed during ginning within the regulated areas. Oklahoma has never required it.)

Cotton planting seed that receives the approved hot-water treatment for hastening germination or that is delinted at approved acid or



BN-7207

FIGURE 3.—Federal pink bollworm quarantine design specifications for fan inlet adapter for oversized pipe and single fan used in treating cottonseed hulls, linters, and motes. The adapter must extend past the housing wall. ("F" signifies the diameter of the fan inlet.)

TABLE 10.—*Federal pink bollworm quarantine requirements regarding wheel diameter, inlet size, and speed of operation of single fans for treating linters and oil-mill waste*

Fan wheel diameter (inches)	Maximum inlet size	Minimum speed	Maximum safe speed
18		2, 548	3, 185
18½		2, 479	3, 099
19		2, 414	3, 018
19½		2, 348	2, 935
20		2, 294	2, 868
20½		2, 235	2, 793
21		2, 186	2, 732
21½		2, 135	2, 669
22	7	2, 083	2, 604
22½	7	2, 041	2, 551
23		1, 993	2, 492
23½		1, 951	2, 439
24		1, 911	2, 388
24½		1, 872	2, 340
25		1, 835	2, 294
25½		1, 799	2, 249
26	8	1, 765	2, 206
26½	8	1, 729	2, 161
27		1, 700	2, 125
27½		1, 700	2, 083

mechanical-flame delinting plants may now be certified by quarantine officials for movement out of the pink bollworm quarantine area without further treatment.

SUMMARY

Investigations were carried out in 1953-56 to determine the pink bollworm kill resulting from cotton-gin and oil-mill processes and, if possible, to find ways of increasing it. Associated tests dealt with pink bollworm kill caused by delinting and hot-water treatment of cottonseed intended for planting. Tests were made at the Southwestern Cotton Ginning Research Laboratory, Mesilla Park, N. Mex., at many commercial gins, at a modern oil mill, and at three seed-delinting plants.

In the ginning laboratory, results of tests on infested snapped cotton indicated that ginning with the simplest setup had killed 84 percent of the worms in seed taken at the gin stand, and that adding machinery until the gin setup became an elaborate one had increased the kill to more than 99 percent. Results with infested handpicked cotton showed a similar trend. Further kill was caused by the seed-blow system. The large numbers of live pink bollworm larvae found in the gin trash confirmed the need for treating this material to kill the worms. In tests with commercially ginned seed, like results were obtained regarding pink bollworm mortality in ginning.

Tests were made with fans of the kinds commonly used for treating trash as it occurs in the ginning operation and for moving motes and linters to the press at oil mills. Such fans, whether their housings were unlined or had rubber linings, were found to kill all pink bollworms in gin trash and in linters, motes, and hulls if designed and operated according to specifications developed as a result of the research reported here. These specifications have accordingly been approved by the Plant Pest Control Division, Agricultural Research Service, as pink bollworm quarantine requirements.

Investigation of treatments commonly applied to cottonseed intended for planting showed that 100 percent of the worms in infested seed were killed by the standard acid or mechanical-flame delinting process or by the hot-water treatment commonly applied to hasten germination—immersion in water at temperatures between 160° and 180° F. for 1 to 2 minutes. As a result of this finding, cotton planting seed that is delinted at approved acid or mechanical-flame delinting plants or that receives the approved hot-water treatment for hastening germination may now be certified for movement out of the pink bollworm quarantine area without further treatment.

Owing to the high pink bollworm kill in the normal ginning operation and the further kill in oil-mill processing or planting-seed treatment, it is concluded that the survival in cottonseed has little, if any, importance when the seed is used within the generally infested area. This finding has led to abolition by Texas and New Mexico of their regulations requiring heat treatment of cottonseed at gins.